1-1-1981

Glacial Geology of Southern Rhode Island

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GLACIAL GEOLOGY OF SOUTHERN RHODE ISLAND

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ITINERARY

STOP 1. The "University pit", north-northwest of University of Rhode Island, 0.25 mile north-northeast of 124 foot road intersection, in northeast part of Kingston quadrangle.
South Pit - This pit is in a broad outwash plain, and the southern part of the pit exposes flat undisturbed sand and pebble gravel with stream crossbedding. The outwash is mantled by the late-glacial windblown material, which shows late-glacial frost disturbance. The boulders encountered in the east edge of the pit may well be from till beneath the outwash, the buried continuation of the adjacent till hillside.

North Pit - This pit has usually provided the best exposures of late-glacial frost features in Rhode Island. The uncollapsed part of the outwash shows abundant involutions in the lower part of the eolian material and extending down into the top of the gravel. These involutions are approximately symmetrical in vertical section and equidimensional in horizontal section, and may easily be distinguished from load casts or from wind-throw structures. This part of the pit has produced about eight ice-wedge structures over the years. The wedges vary from about 1 to 2 feet wide at the top, and end at depths of 6 to 9 feet. They are known from very few localities, and as far as we can tell from their orientation, they occur only as separate structures, not as nets. The perennially frozen ground that they indicate might have been only thin and patchy.

In the southwest part of the pit, the outwash shows collapse structure related to the adjacent kettle. This kettle was partly filled with windblown material and gravel, redeposited from the adjacent slopes by local slopewash. Near the kettle, poor drainage conditions have produced unusual color effects through the action of groundwater, including local cementation by crusts of iron oxide.

EN ROUTE TO STOP 2.

We travel about 2000 feet north on the outwash plain, into the Slocum quadrangle.

STOP 2. Small moraine 0.5 mile east of Hundred Acre Pond, in southeast part of Slocum quadrangle.

Walk along road across this moraine, which stands at the head of the outwash plain of Stop 1 and was deposited at the edge of the ice from which the outwash rivers came. The moraine is a bouldery ridge, distinctly higher than the adjacent outwash. A small pit shows collapsed sand and gravel and a little till, with many boulders (one of which is strongly fluted by wind abrasion). The bed of the brook that descends the north or ice-contact face of the moraine contains a lag concentration of large boulders.

This moraine appears to be part of a thin line of morainic features rising out of the outwash in the north central and northwestern parts of the Kingston quadrangle.

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On the Kingston quadrangle geologic map a long narrow ridge situated about 2 miles west-southwest from Stop 2 is labelled crevasse-filling. A mile or so further west, a belt of kamy hills cuts across the Usquepaug Valley. Plate 33 of the Kingston quadrangle report suggests an ice front responsible for this thin morainic belt. If these features are correctly interpreted, then the ice readvance or retreatal still-stand at this line was certainly a minor affair.

EN ROUTE TO STOP 3.

Road is on outwash plain that appears to head a small moraine that crosses the valley of the Chipuxet River in the Slocum quadrangle, just north of the Kingston quadrangle. South from Rte. 183, Ministerial Road crosses the deltaic front of this outwash plain where it built out into Glacial Lake Worden, a glacial lake dammed in part by the Charlestown moraine, which is to our south here. Most of the area of Glacial Lake Worden is now occupied by a large swamp, the Great Swamp, famous as the place where King Philip and his Indians were finally depeated by the colonists in 1675.

The road climbs a till-mantled rock knob, Tobey Neck, that arises from the swamp, and then crosses several patches of outwash gravel lying just north of the Charlestown moraine.

STOP 3. North side of Charlestown moraine on Ministerial Road, 0.65 mile south of Tuckertown Four Corners, in central part of Kingston quadrangle.

View of Charlestown moraine from the north. The moraine rises abruptly with a steep north slope. This slope is the north side of a ridge-like feature (look back at it as we travel into the moraine) that parallels the trend of the moraine. Though not shown as such on the geologic map (Kaye, 1960), it probably should be classified as a colluvial rampart, that is, a talus that accumulated against the north side of the ice core that underlay the Charlestown moraine after ice to the north had disappeared (to be discussed in more detail under Stop 3). The moraine is 1.4 miles wide (north-south) here, which is close to its maximum width. We are about 1.5 miles from its eastern end.

EN ROUTE TO STOP 4.

As we cross the moraine, notice the ridges and hills on both sides of the road. Seen from the air many of the ridges are sinuous to angular in plan, and the hills, or mounds, are oval to subround. A striking feature of the mounds is that they have flat tops commonly surrounded by a low rim. Just right of the road is Broad Hill, one of the best formed of the rimmed mounds. These are called ice-block casts (Kaye, 1960) and are thought to represent sediment that accumulated in depressions in the ice core that underlay the moraine during its formative years. These holes were caused by the more rapid melting of some blocks of ice, in comparison to the rate of melting of the surrounding ice.

The road descends to the sloping plain south of the moraine. We then go east along the south edge of the south edge of the moraine and the north edge of the outwash plain that heads up to it (US 1); then south on Matunuck Beach Road.

STOP 4. Hilltop south of Matunuck School (Blackberry Hill).

This gives us a general view of the Charlestown moraine and the terrain to the south and east of it.

South of the moraine, a surface of low relief grades gently south to sea level. This sloping plain consists of broad coalescing fans of outwash that originated at the ice front of the Charlestown moraine. Projecting through the outwash in several places, including the site of Stop 4, are low elliptical till-mantled hills (drumlins?) and a few patches of ground moraine that were not buried by outwash.

The till south of the Charlestown moraine seems to have about the same composition and degree of oxidation an soil development as the till in the moraine and north of the moraine. For these reasons, it may be about the same age as the moraine.

The Charlestown moraine is largely made up of ridges and mounds. The ridges, generally sharply sinuous to curved in plan, range from 5 to 100 feet in height and from the pattern they inscribe on the map (Kaye, 1960) appear to be crevasse or ice-fracture fillings.* The mounds have about the same range in height as the ridges and commonly have a flat top rimmed with a low ridge which also reflects a crevasse, or ice-fracture filling origin. It is suggested that these mounds represent sedimentation in holes in the ice. The holes resulted from the more rapid melting of blocks of ice isolated by fractures and the rimmed tops reflect these marginal fractures by a topographic inversion (Kaye, 1960). Here again, the reasons for preferential melting could profitably be discussed.

The Charlestown moraine is thought to have formed because of a belt of shear planes along the ice front. This resulted in a band of dirty ice in the marginal zone, which in turn produced a belt of thick ablation moraine. As the underlying ice melted, the ablation moraine shifted both by sliding and water transport into low places on the ice surface. The present topography of the moraine is essentially an inversion of the ice surface during the last stages of wastage--that is, high places on the ice core are represented by topographic lows, and ridges and mounds mark places where core ice was thin or absent.

The cleaner ice north of the moraine melted more rapidly than the debris-covered ice. As a result, for a long while the Charlestown moraine had a thick ice core that was isolated from the ice sheet to the north. Drainage from the deglaciated tract north of the moraine was partly submoraine, that is, meltwater flowed beneath the surface of the moraine through ice tunnels and enlarged crevasses in the ice core. In the Kingston moraine this submoraine drainage seems to have been largely localized at two places. These are both marked by deep pond-filled kettles and a sag in the crestline of the moraine. In short, there is a deficiency of material making up the moraine along these drainageways. This is probably the result of the flushing action of the subsurface drainage, washing away rock debris in the crevasses and englacial debris from the walls of the drainage channels.

These sags can be seen from Stop 4. One is north of Stop 4 and the other is to the WNW. It is interesting to note that the outwash fans head up to these drainageway sags and that a series of ponds and channelways also head up to what must have been the springs at the outlets of the submoraine drainage.

About a mile northeast of Stop 4, the ridges and mounds of the Charlestown moraine decrease rather abruptly in height and the moraine blends into a low hummocky topography that is marked here and there by low ridges, angular to sinuous in plane like the ice-fracture fillings of the Charlestown moraine but on a reduced scale.

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*("Ice-fracture filling" is preferable to "crevasse-filling" as a term here because to some, "crevasse" denotes a dynamically formed fracture. The fractures indicated, on the other hand, do not have the pattern or the orientation of the typical crevasse fractures resulting from ice movement. They seem to suggest tension (?) fractures that might, for example, form in massive stagnant ice because of stresses brought on by unequal melting. This problem would be worth discussing here.)

This low hummocky area makes up the southeastern part of the Kingston quadrangle and extends from the shore north to Wakefield. Two large salt ponds, Point Judith Pond and Potter Pond, are situated in this belt.

The low hummocky area is underlain mainly by gravel and sand but interbedded with these are rather extensive lenses of till. The till is dark gray in color, unlike the nearly white till of the Charlestown moraine, and is rich in the graphitic metasedimentary rocks of Pennsylvanian age of the Narragansett basin. There is a zone of mixing along the east end of the Charlestown moraine and the western edge of the low hummocky area where debris both from dark Narragansett basin rocks and light crystalline rocks occur together in the drift.

This low hummocky terrain is thought to represent a thick and relatively extensive ablation moraine. This is in contrast to the Charlestown moraine where the ablation moraine was confined to a narrow marginal zone of dirty ice. It is referred to on the Kingston quadrangle map as the "Ablation-moraine complex of the Narragansett basin ice". It grades both upward and northward into deposits that can be called ice-contact deposits. The boundary between the two types of deposits is arbitrary.

The ablation moraine complex of the Narragansett basin ice is probably the same age as the Charlestown moraine and may represent a lobate projection of the ice sheet in this section beyond the line of the Charlestown moraine. The narrow belt of moraine-laden shear planes of the Charlestown moraine gave way to a broader development of shearing and dirty ice in the Narragansett basin lobe. On melting, the difference in englacial moraine per unit area of ice (greater in the Charlestown moraine) produced a difference in the ultimate thickness of ablation moraine, and thus in the resulting morainic topography.

EN ROUTE TO STOP 5.

We will return to Rte. 1 and travel east along the toe of the moraine. Then the buses will travel northeast along the edge of the ablation moraine complex of the Narragansett basin ice to Wakefield, and then south along Point Judith Road. This road follows the crest of a ridge that is shown on the surficial map of the Narragansett Pier quadrangle as the Point Judith moraine, believed to have been deposited at the west side of the Narragansett Bay-Buzzards Bay ice lobe. The topography of moraine ranges from smoothly rolling to moderately knobby, and is more irregular to the south; but nowhere does it show the very sharp topography and distinctive form elements of the Charlestown moraine. The material is dominantly till, generally contains thin layers and lenses of sand, gravel, and silt, and was evidently deposited as ablation moraine. Known depths to bedrock range from 10 feet near the west end of Clarke Road to 95 feet at Fort Greene.

Continue south on Rte. 108, then west almost to Sand Hill Cove.

STOP 5. Shore cliff 0.5 mile northwest of Point Judith lighthouse, in southwest corner of Narragansett Pier quadrangle.

If the weather is clear, we will see Block Island 13 miles south, about at the position of maximum extent of the last ice sheet.

This cliff exposes ablation-moraine deposits, consisting of till and till-like material interbedded with sand and silt. The bedding is more-or-less deformed, presumably as a result of collapse, but some of the strong contortion in the upper part may be frost involutions. On top is late-glacial eolian sandy silt with ventifacts (wind-abraded stones). The beach gravel is coarse, poorly rounded, and thin, and lies on a platform eroded in till.

Most of the stones are of nearby crystalline rocks, especially the reddish granite and pegmatite as at Stop 9. The abundant gray Pennsylvanian sedimentary rocks were carried southwest from the Narragansett basin. Rare red sandstone and rhyolite come from the northwest part of the basin, near Attleboro. Two cobbles of cumberlandite (magnetite-rich peridotite) found on the beach here represent the west edge of the indicator fan of this very distinctive rock, derived from a small outcrop area 44 miles north (just east of Woonsocket).

The short, low cliff just west of the main cliff shows a soil profile developed under poorly drained conditions. The sag between these cliffs is the landward side of a former shallow kettlehole, now breached by marine erosion. A remnant of an organic deposit formed in this kettle occurs on the beach, covered by beach gravel; it contains abundant wood (much of which shows beaver tooth marks) and a few spruce cones. Pine wood from this deposit gave a radiocarbon age of 10,906 ± 112 years (OWU-22).

EN ROUTE TO STOP 6.

Travel north on Ocean Road. At Fort Greene, a boring west of road pentrated about 95 feet of glacial deposits on top of granite; east of road, near old coastal observation building, is a 34 foot granite boulder, the largest glacial boulder in this area. Continue north past the broad sand beach at Scarborough.

STOP 6. Shore point at end of Newton Avenue, midway between Indian and Gunning Rocks, in south part of Narragansett Pier quadrangle.

The shore here is composed of reddish granite, with many crosscutting dikes of coarse pegmatite and some inclusions of older schist (probably the Pennsylvanian rocks). Close to the end of the avenue, the granite shows glacial grooves from N 20°E. Glacial erosion controlled by joints in the granite produced stoss-and-lee topography: gentle upstream or stoss slopes and steeper lee slopes. On the southwest side of the point, till buries the main lee scarp. Wave erosion has stripped off till, but has eroded relatively little granite except in zones of close jointing. Southward from the point, joint blocks are progressively worn into rounded boulders by wave action in storms. Some patches of granite show distinctive salt weathering. This bedrock shore is of course more stable than is a shore composed of easily eroded glacial deposits as at Stop 5.

EN ROUTE TO STOP 7.

Travel north through Narragansett Pier, then west to US 1. Go north on US 1.

STOP 7. Esker, Pendar Road (formerly Old Post Road), 0.4 mile north of Shermantown Road, in southwest part of Wickford quadrangle.

Just before the stop, the south part of Pendar Road crosses a somewhat collapsed gravel plain, deposited by glacial melt-water streams that drained southwest from the ice onto the upland. The esker is the cast of one of the streams, and is part of the strongly collapsed ice-contact head of the deposit, which contains many kettles. The topography is very well shown along a trail that leads northwest from the road, at the southwest end of the esker. The road follows the crest of the esker for a short distance. Here as at many other stops we can see some of the diversification of habitats caused by glaciation.

The esker is part of the kettle ice-contact head of sequence 2a, which drained southwest over the upland to Saugatucket River. This head stands nearly 100 feet above the deposits of sequence 4, which drained southeast along Mattatuxet River.

EN ROUTE TO STOP 8.

We travel north and northwest, and then west on West Allentown Road, across deposits of sequence 4 and 3 and "morainic kames". The morainic kames, which are unpredictable mixtures of till and water-laid materials, are the first ice-hole deposits laid down as the ice melted away from the moraine to the west. We travel across the moraine, and then onto the outwash plain west of it.

STOP 8. Indian Corner Road, east of Slocum.

This stop is in the midst of the potato fields that occupy most of this extensive outwash plain. The plain is correlated with the moraine that lies along the boundary between the Slocum and Wickford quadrangles. A high part of the moraine (about 80 feet above the outwash plain) lies directly east of this stop.

EN ROUTE TO STOP 9.

Return to US 1, travel north Rte. 102, then east.

STOP 9. Pit on north side of Route 102, 0.3 mile east of circle intersection with Routes 2 and 4, in west-central part of Wickford quadrangle.

This pit in a kame shows ideal ice-contact features. The materials range from sand to boulder gravel, mostly well bedded and well sorted, but some poorly sorted. There is much lensing and abrupt change in texture. The materials were deposited on and against motionless remnants of glacier ice, and the melting of that dead ice produced collapse, with strong faulting and folding of the beds.

EN ROUTE TO STOP 10.

North on Route 2, and west at Pontiac on north side of Pawtuxet River floodplain. Floodplains are a very minor part of the Rhode Island landscape, and are very subject, as here, to spoilation by man: pollution (note sewage disposal plant) and filling (for highways and buildings). Continue west, past Natick, up the west scarp of Narragansett basin (basal Pennsylvanian conglomerate on southwest side of road) and across upland to Harris; then north on Lippitt Avenue and east on private road.

STOP 10. "Rottenstone" pit north of Harris, on west side of private road, 800 feet north of 258 foot intersection, northeast part of Crompton quadrangle.

This weathered granite is in one of several extensive areas of weathered bedrock in Rhode Island, mostly in coarse granitic rocks, and more then 15 feet thick in some places. The weathering generally consists of disintegration caused by slight chemical decompostion of feldspar and biotite, and commonly reveals a platy structure. Spheriodal weathering controlled by joints produces core stones, which here are flattish ellipsoids. This weathered rock presumably is only the lowest part of a once much thicker weathered zone (comparable to that of the Piedmont province along the east side of the Appalachians, south of the limit of glaciation), but the rest has been eroded away, mostly by the successive glaciers. It is overlain here by unweathered light-gray granitic till; therefore, the weathering is older than the last glaciation and perhaps than the entire Ice Age.

EN ROUTE TO STOP 11.

(8 miles) South through Harris and West Warwick to Crompton, mostly on till-bedrock hills; then southwest on New London Turnpike and west on Division Road, mostly on a broad terrace of glacial sand and gravel.

STOP 11. Sand pit on north side of Division Road at 277 foot intersection, southeast of Mishnock Pond, in southwest part of Crompton quadrangle.

This is the eastern of two large pits in thick sand that was probably deposited in a glacial lake. On the east side of the entrance to the pit is exposed the post-glacial soil, developed on late-glacial windblown sandy silt that overlies the glacial-lake deposits; this soil is now buried by sand blown from the pit since the pit was opened. The pit has been worked hardly at all for 15 years or more. During this time, small phytogenic dunes of sand held by clumps of vegetation have been built at the east side of the pit; the plants principally responsible are sweet-fern (Comptonia peregrina), bramble (Rubus), and a sedge (Carex). Also during this time, the west and northwest sides of pebbles in some parts of the pit have been polished by wind-driven sand. The sand also shows wind ripples and other features. This "Desert of Rhode Island", like other such "deserts" in New England, was caused by destruction of the original vegetation by man.

END OF TRIP

EN ROUTE TO STOP 11

(Continued). South through Hopkinton and west Warwick to Coventry, north on 117 to Hill, then northwest on New London Turnpike and north on Plainfield Pike, across mostly on a broad terrace of glacial sand and gravel.

STOP 11. Sand pit on north side of Plainfield Road at 277 feet elevation, a mile east of Hopkins Road, in southeast part of Crompton quadrangle.

This is the eastern of two large pits in deltaic sand that was probably deposited in a glacial lake. On the east side of the entrance to the pit is exposed the post-glacial soil, developed on late-glacial windblown sandy silt that overlies the glacial-lake deposits; this soil is now buried by sand blown from the pit since the pit was opened. The pit has been worked only at all for 15 years or more. During this time, small vegetation masses of sand held by clumps of vegetation have been built at the east side of the pit; the plants principally responsible are sweet-fern (Comptonia peregrina), bramble (Rubus), and a sedge (Carex). Also during this time, the west and northeast sides of pebbles in some parts of the pit have been polished by wind-driven sand. The sand also shows wind ripples and other features. This "desert of Rhode Island", like other such "deserts" in New England, was caused by destruction of the original vegetation by man.

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